Absolute Radiometric Calibration of the DigitalGlobe Fleet and updates on the new WorldView-3 Sensor Suite

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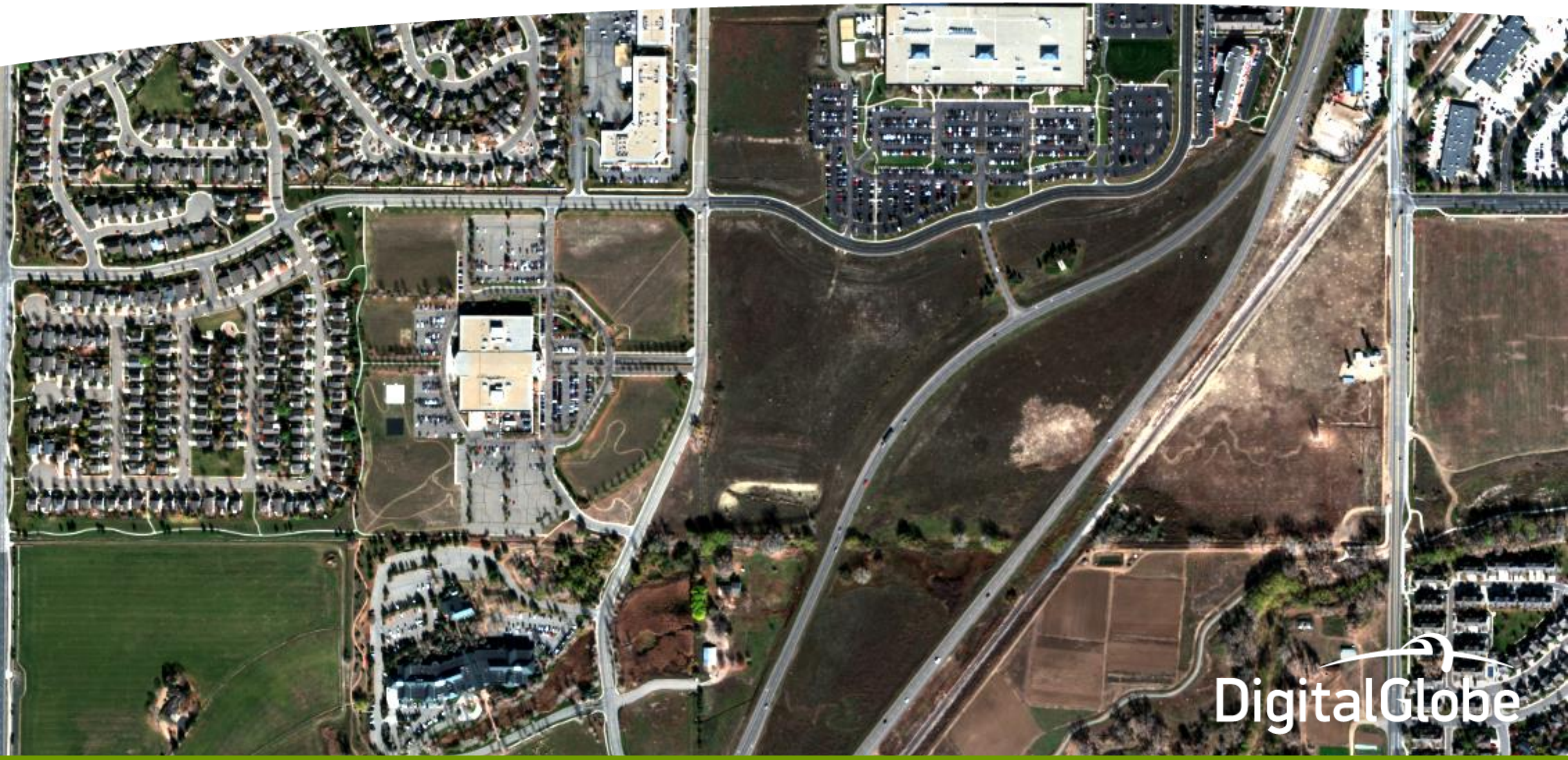
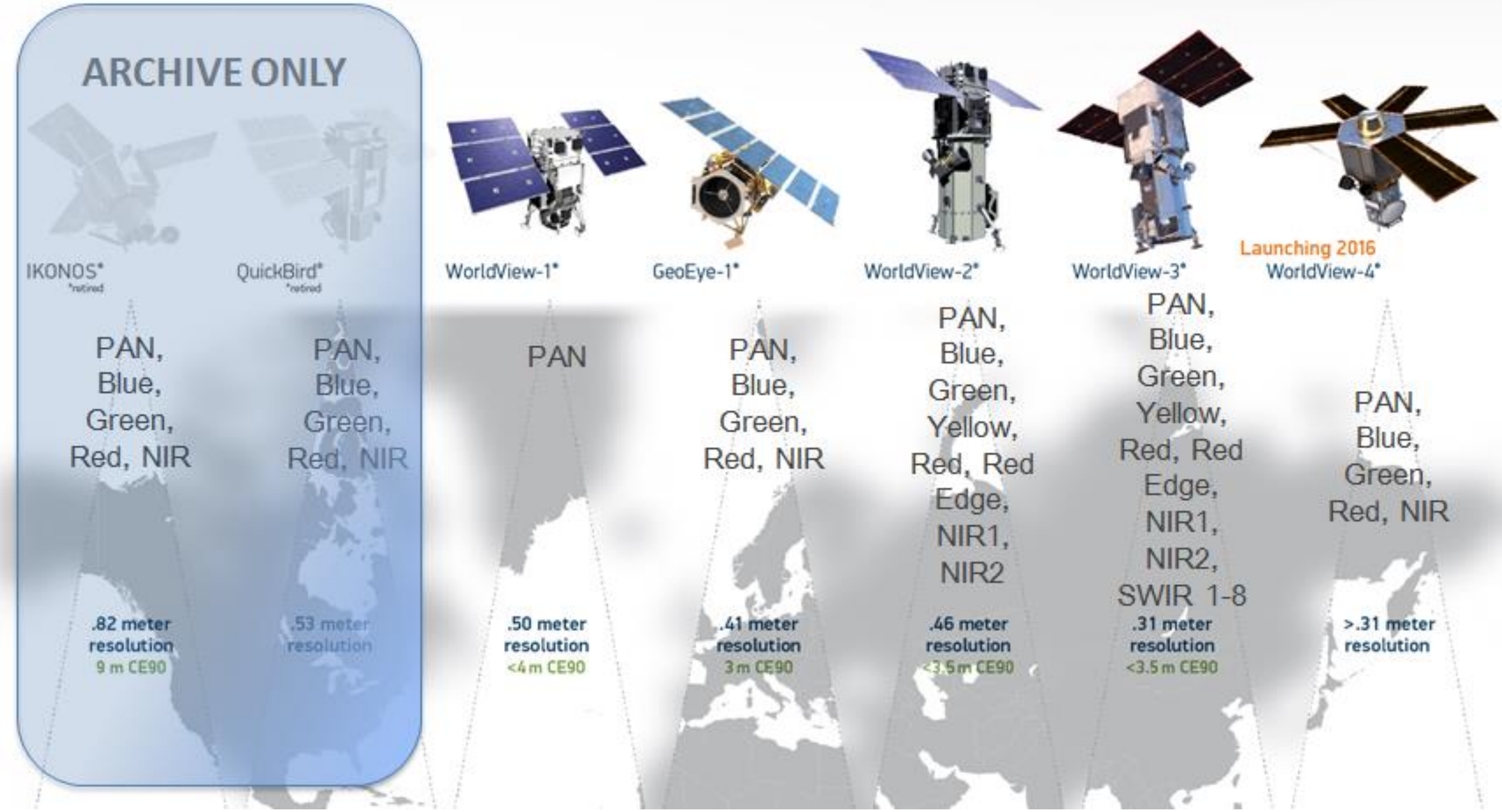


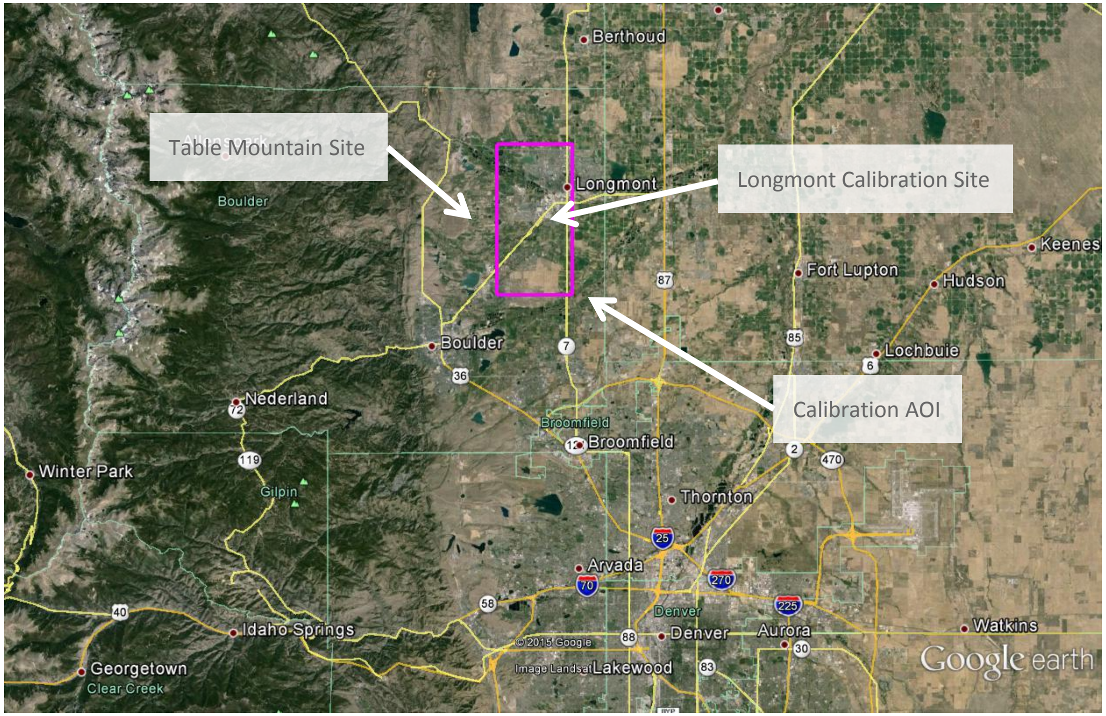
Overview

- DigitalGlobe Constellation
- Vicarious Calibration Site & Approach
- DigitalGlobe adjustment factors to the pre-flight absolute radiometric calibration
- Improvements since last season
- Internal validation
- Next Steps

DigitalGlobe Constellation

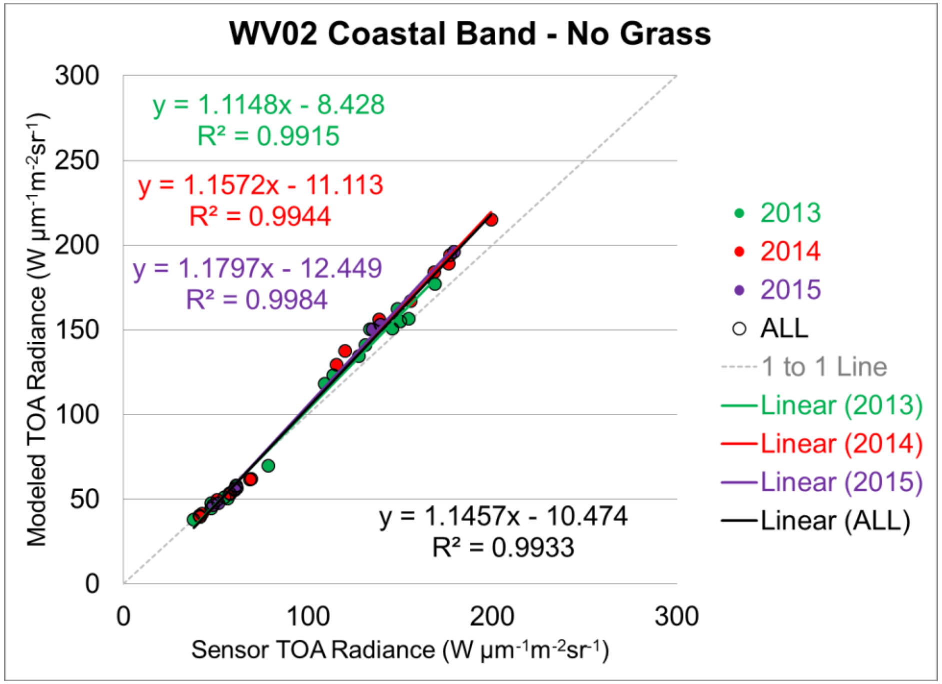


DigitalGlobe Calibration Site at Longmont, CO, USA



Vicarious Calibration Approach: Reflectance-based

- In-situ measurements used in radiative transfer code (MODTRAN) to calculate top-of-atmosphere radiance to compare to sensor
- Angular dependent reflectance of calibration targets
- Table Mountain AERONET for aerosol optical depth, water vapor, sing scattering albedo and asymmetry
- On-site Yankee MFR-7 shadowband radiometer (validation) – L1 Rooftop always running in-season
- Weather station (temperature, pressure)



How to Apply the New Calibration

- A pre-flight calibration data are provided in the .IMD metadata file delivered with the imagery
- Since launch, DigitalGlobe has performed an extensive vicarious calibration campaign to provide an adjustment to the pre-launch values
- Top-of-atmosphere radiance, L, in units of Wμm^{-1} m^{-2} sr^{-1}, is found for each band by converting from digital numbers (DN)

$$L = GAIN * DN * (\frac{abscalfactor}{effectivebandwith}) + OFFSET$$

Please Note: Equation has changed from last year!

- Updates and radiometric use documents may be found here:

http://www.digitalglobe.com/resources/technical-information

DigitalGlobe

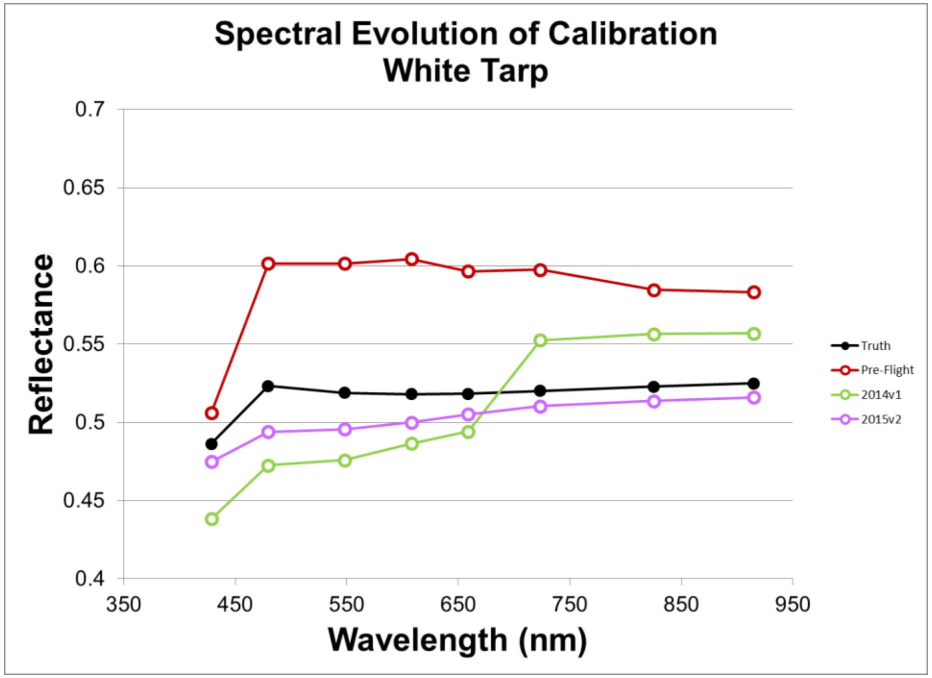
New Calibration Adjustment Factors

	DigitalGlobe Calibration Coefficient Adjustment Factors as of 1/29/2016											
	WORLDVIEW-3		WORLDVIEW-2		GEOEYE-1		QUICKBIRD		IKONOS		WORLDVIEW-1	
CAL VERSION	2015v2		2015v2		2015v2		2014v3		2014v3		2015v2	
BAND	GAIN	OFFSET	GAIN	OFFSET	GAIN	OFFSET	GAIN	OFFSET	GAIN	OFFSET	GAIN	OFFSET
PAN	0.923	-1.700	0.960	-2.957	0.978	-1.948	0.876	-2.157	0.907	-4.461	1.016	-3.932
COASTAL	0.863	-7.154	1.146	-10.474								
BLUE	0.905	-4.189	1.003	-7.795	1.059	-6.590	1.121	-5.427	1.073	-9.699		
GREEN	0.907	-3.287	0.953	-4.047	1.001	-4.352	1.084	-4.779	0.990	-7.937		
YELLOW	0.938	-1.816	0.965	-3.467								
RED	0.945	-1.350	0.969	-2.257	1.009	-3.222	1.068	-3.492	0.940	-4.767		
REDEDGE	0.980	-2.617	1.003	-4.103								
NIR1	0.982	-3.752	0.981	-3.081	1.011	-4.085	1.024	-5.096	1.043	-8.869		
NIR2	0.954	-1.507	1.037	-2.818								
SWIR1	1.160	-4.479										
SWIR2	1.184	-2.248										
SWIR3	1.173	-1.806										
SWIR4	1.187	-1.507										
SWIR5	1.286	-0.622										
SWIR6	1.336	-0.605										
SWIR7	1.340	-0.423										
SWIR8	1.392	-0.302										

WV03, GE01 and WV01 based on data collected 2014 & 2015
WV02 based on data collected 2013, 2014 & 2015
IK02 and QB02 based on data collected 2014

release date: 2/22/2016

Absolute Radiometric Calibration Evolution



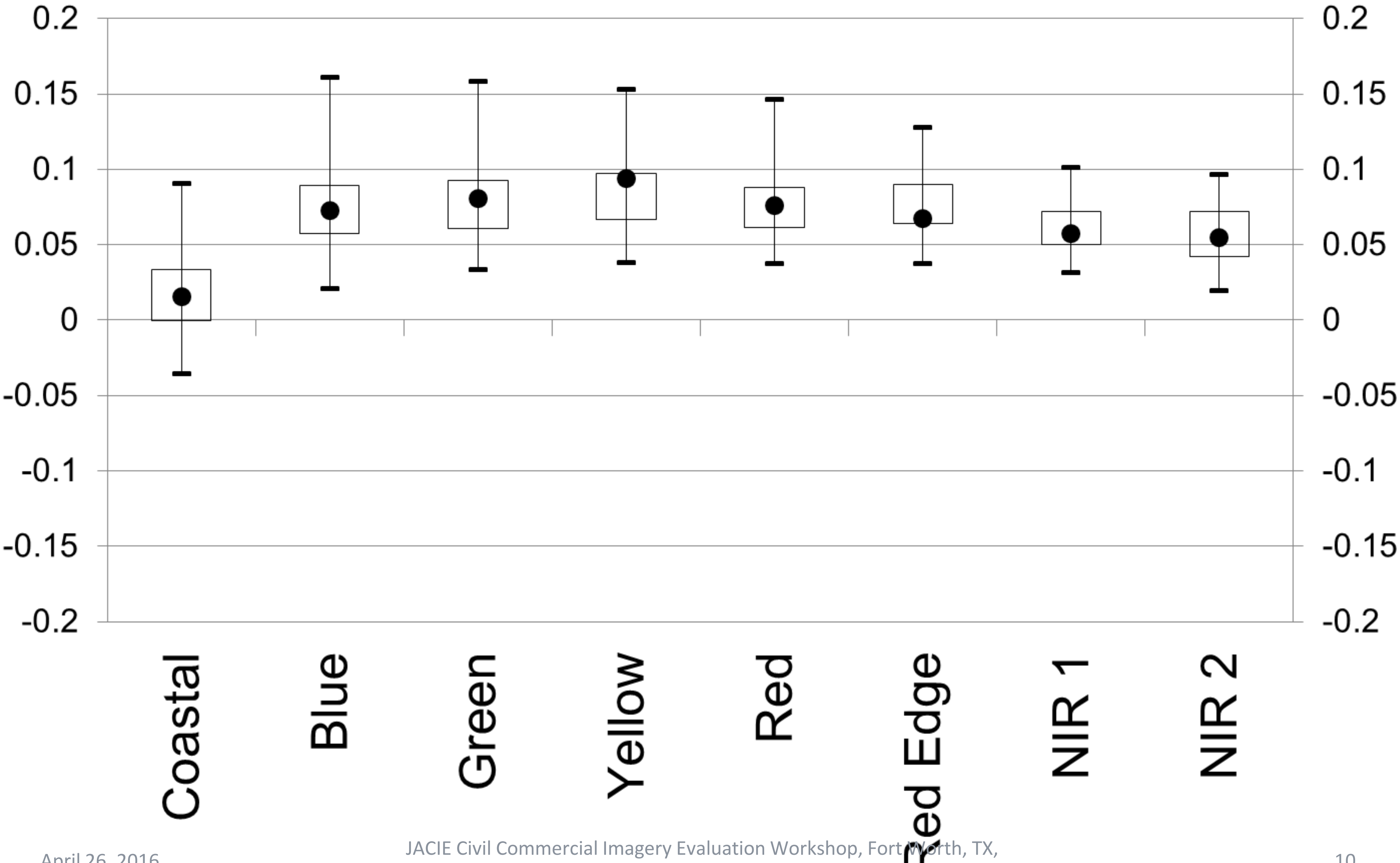
WorldView-2

- 2014v1: Presented last year at JACIE
- 2015v2: Improvements from last:
  - Atmospheric input divided into 4 vertical layers
  - SSA & measured asymmetry parameter now included
  - Water vapor retrieval from Shadowband and methodology proved out
  - Ozone now based on DOY climatology versus MODTRAN default
  - All code consolidated into an end-to-end Python executable
  - Upgraded to MODTRAN 5.3.3

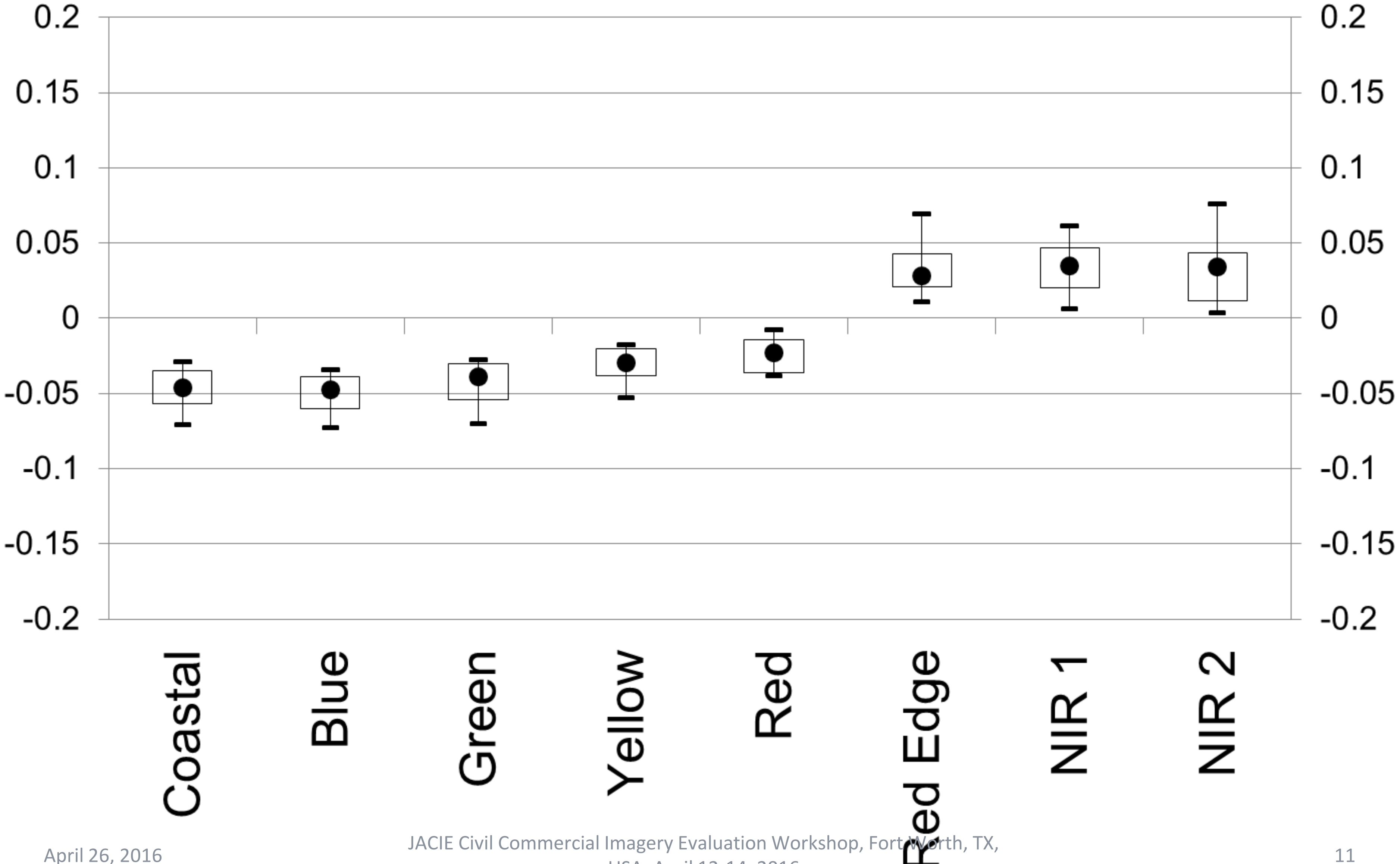
Internal Validation:
Description for upcoming slides

- Internal reflectance product (DG-AComp) used as a validation tool for the absolute radiometric calibration coefficients
- Looking at white tarp in Longmont, CO, USA, with sensor TOA radiance input calculated by
  - Pre-flight: Only abscalfactor IMD values applied to imagery
  - 2014v1: Previously described – released in 2015
  - 2015v2: New methodology – released in 2016
- WV02 Includes 8 days from June through October in 2014
- WV03 includes 10 days from June through October in 2015
- Reflectance measurements made on ground with ASD Field Spectrometer at correct angles considered "Truth"
- Truth subtracted from average of pixels on targets from DG-AComp to give absolute difference (everything on zero line would be "perfect")
- Median(fill circle), Quartile1 (bottom box), Quartile 3 (top box), Min and Max (bottom and top lines) used to create box plots

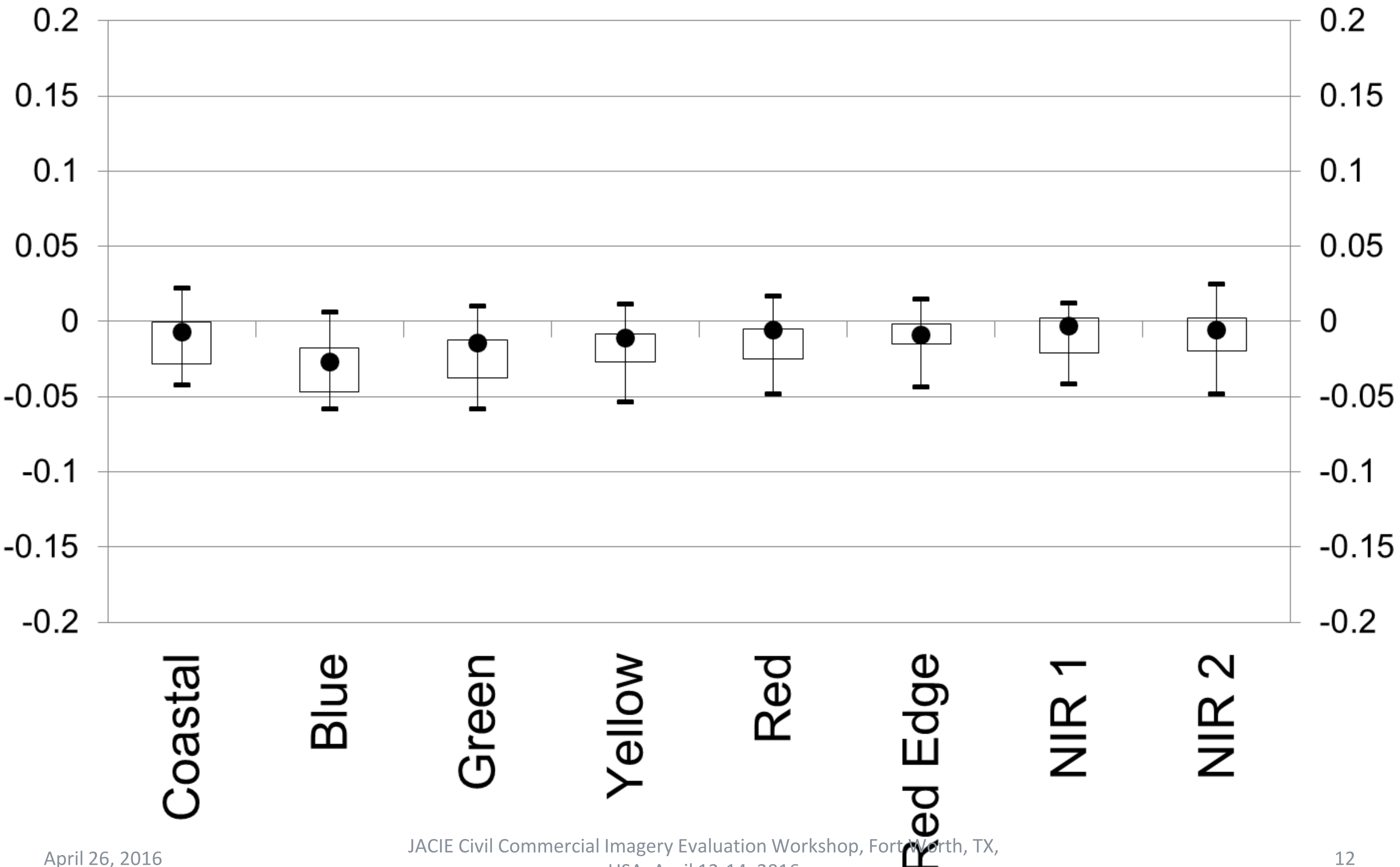
WorldView-2 Pre-Launch Calibration Comparison to Ground Truth over White Tarp



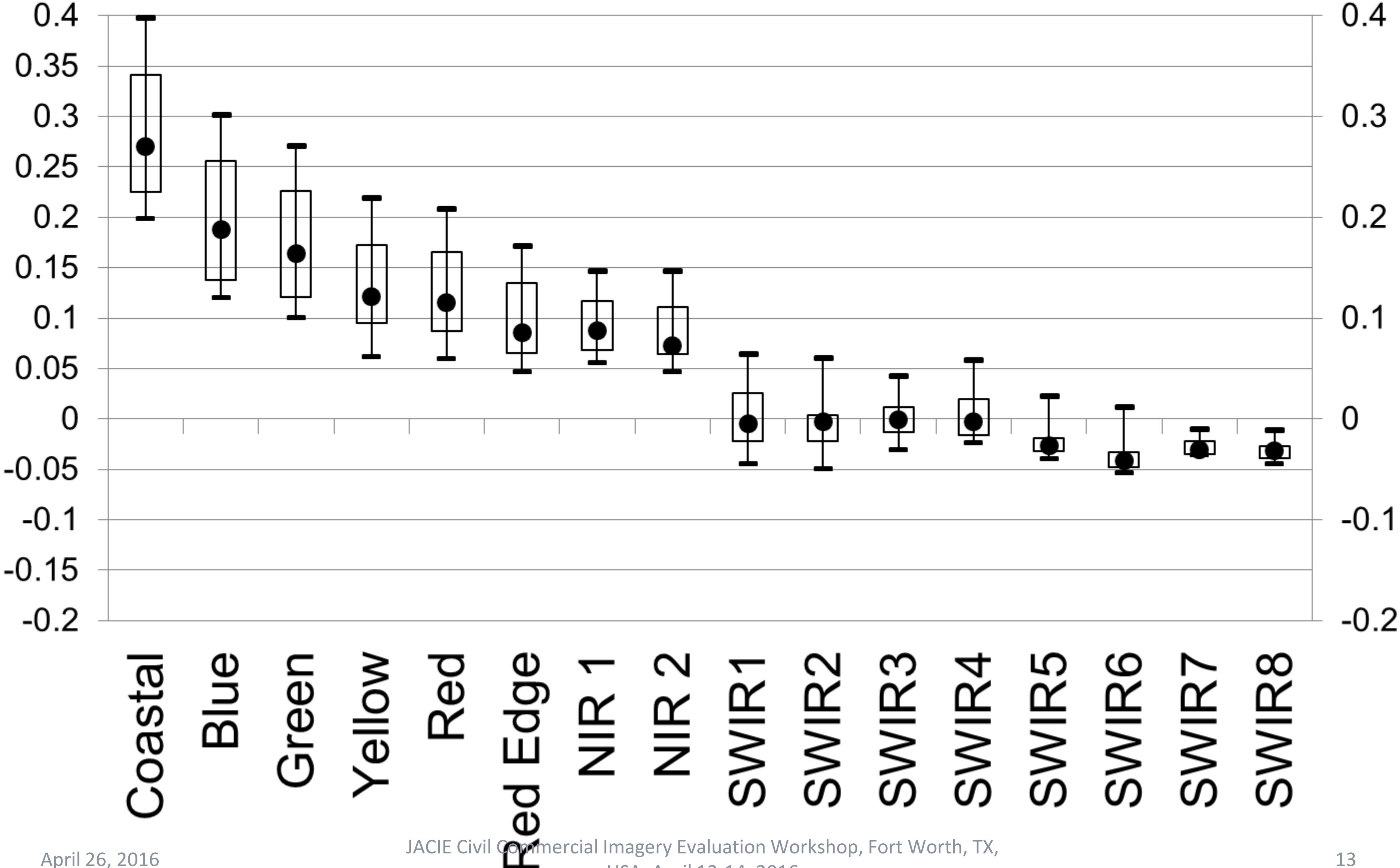
WorldView-2 2014v1 Calibration Comparison to Ground Truth over White Tarp



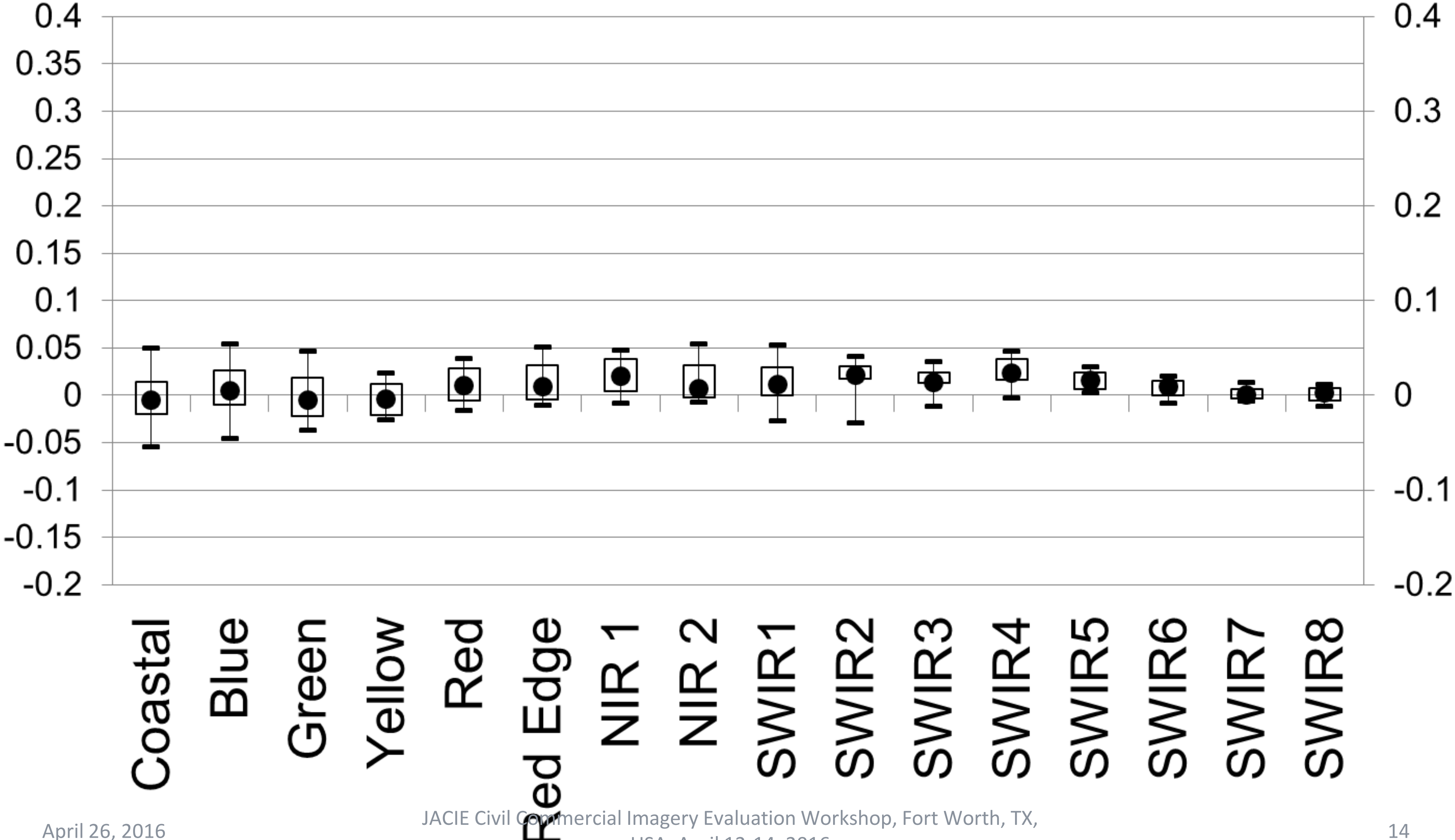
WorldView-2 2015v2 Calibration Comparison to Ground Truth over White Tarp



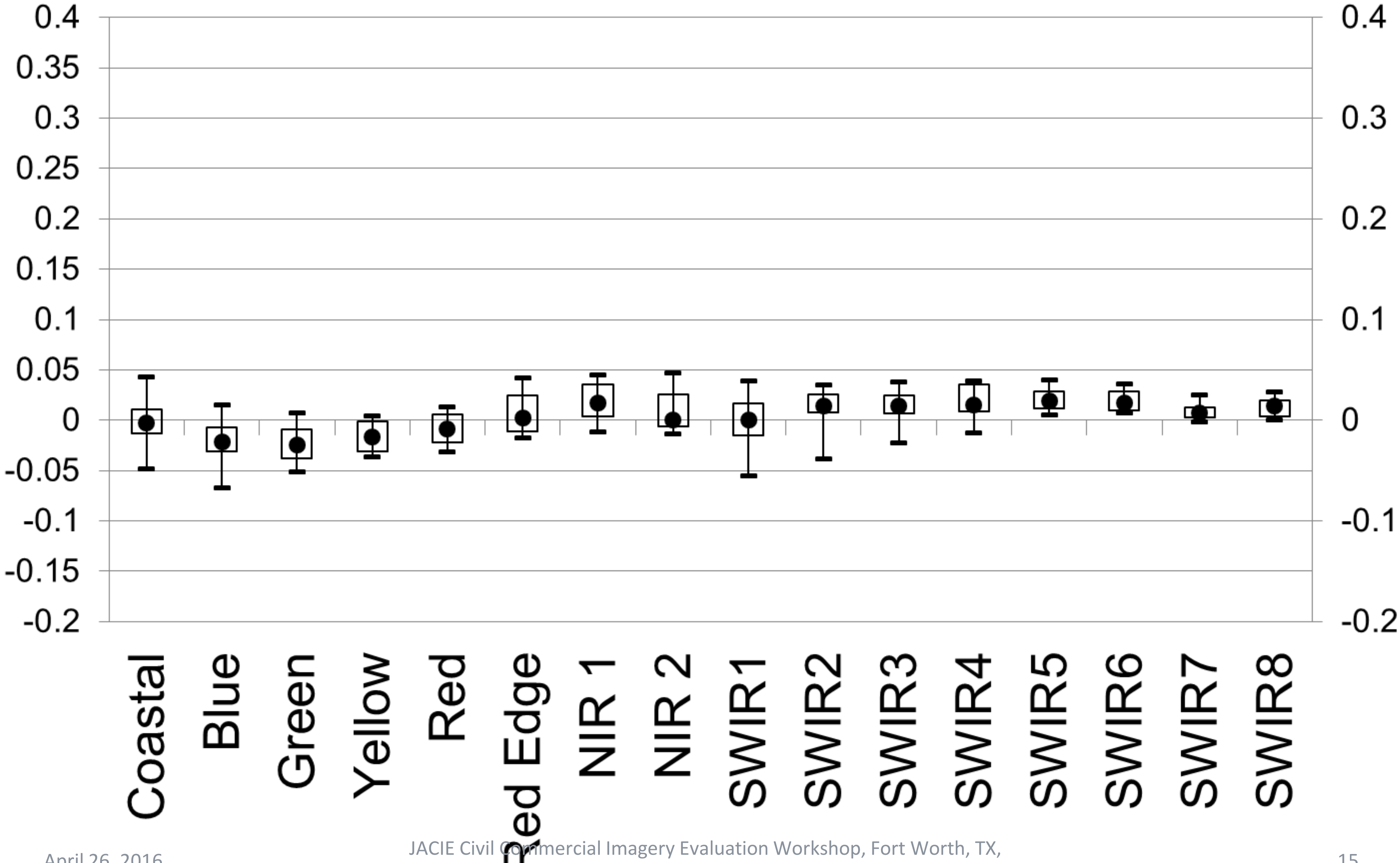
WorldView-3 Pre-Launch Calibration
Comparison to Ground Truth over White Tarp



WorldView-3 2014v1 Calibration Comparison to Ground Truth over White Tarp



WorldView-3 2015v2 Calibration Comparison to Ground Truth over White Tarp



Conclusions and Current Research

- Calibrations are getting tighter with improved methodology
  - Better atmospheric modeling
  - Adjacency considerations
- Parasol Measurements in Season 2016
  - Better understanding of diffuse skylight component to refine offsets
  - Account for scattered light from actual surroundings
- Working on a view of the WorldView-3 stability since launch with Libya-4 data
- Next year we will have WV04!

Special Thanks

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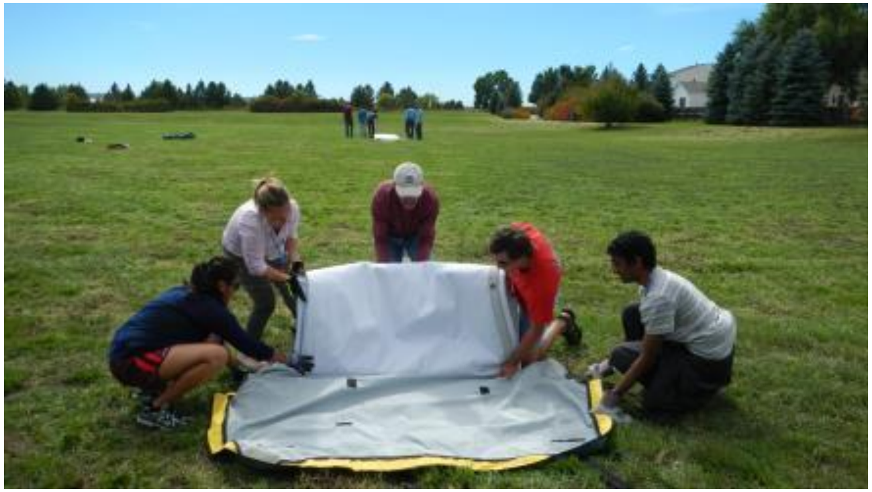
- Patrick Disterhoff, NOAA for upkeep of Table Mountain Research Station
- Colorado Space Grant Consortium interns
- Special thanks to Miguel Ochoa and Alberto Dayer.



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